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Strategic Research Agenda for Utilisation of Earth Observation in Agriculture †

Karel Charvat [1], Vaclav Safar [2], Hana Kubickova [3,*], Sarka Horakova [1] and Tomas Mildorf [3]

[1] WIRELESSINFO, Cholinska 1048/19, 784 01 Litovel, Czech Republic; charvat@wirelessinfo.cz (K.C.); horakova@wirelessinfo.cz (S.H.)
[2] VUGTK, Ústecká 98, 250 66 Zdiby, Czech Republic; vaclav.safar@vugtk.cz
[3] Plan4all z.s., K Rybníčku 557, 330 12 Horní Bříza, Czech Republic; mildorf@plan4all.eu
* Correspondence: hana.kubickova@plan4all.eu
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Abstract: The EO4Agri Strategic Research Agenda (SRA) is a set of recommendations for future research activities in the area of Earth observation for agriculture. The EO4AGRI project provides support to all agri-food sectors based on new uses of COPERNICUS data. At first, part of the deliverable collected user needs from previous work are summarised including gaps in data, delivery platforms and knowledge management. Another input was an analysis of the current political framework and its influence on future agriculture. The implementation of the European Green Deal and the UN Sustainable Development Goals will require future collaboration of the public and private sectors. The main part of the SRA is a list of recommendations for future activities in the Group on Earth Observations (GEO), Horizon Europe (Annex 4 and Annex 6) and the Digital Europe programmes. It is not a revision of these programmes, but additional recommendations or tasks which are important to consider in updating the future programmes.

Keywords: earth observation; agriculture; strategic research agenda; green deal; destination earth

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1. Introduction

Agriculture comprises vital economic sectors producing food, agro-industrial feedstock and energy and provides environmental services through managing soil, water, air and biodiversity holistically [1]. Agriculture including forestry also contributes to managing and reducing risks from natural disasters such as floods, droughts, landslides and avalanches [2]. Farming with its close contact to nature provides the socio-economic infrastructure to maintain cultural heritage. Farmers are also conservers of forests, pastures, fallow lands and their natural resources and, in turn, of the environment [3]. Agriculture today is a composite activity involving many actors and stakeholders in agri-food chains that produce and provide food and agricultural commodities to consumers. In addition to farmers, there are farm input suppliers, processors, transporters and market intermediaries each playing their roles to make these chains efficient [4].

In FutureFarm project [5] a number of external drivers influencing the agriculture sector were detected. The following factors were recognized as the main drivers for changes in the agriculture sector: climate change, demographics (growing population, urbanization and land abandonment), energy cost, new demands on the quality of food (food quality and safety, aging population and health problems, ethical and cultural changes), innovative drivers (knowledge-based bio-economy, research and development, information and communication, education, investment), policies (subsidies, standardization and regulation, national strategies for rural development), economy and financing (economical and financial instruments, partnerships, cooperation and integration and voluntary agreements), sustainability and environmental issues (valuation of ecological performances, develop-

ment of sustainable agriculture) and public opinion (press, international organization, politicians).

The common and future position of each driver can be different in reality. In many cases, two drivers can stand against each other and their future influence on the agri-production and food market depends on regulations and common policy. For example, focusing on food quality and safety could be contradictory with requests for increasing production due to the growing population. Similarly, it is with increasing production and requests on the production of bioenergy. These drivers will lead to decreasing agricultural land, but request to increase production. We need increased quality and safety and it will be connected with a decreasing number of chemical inputs. In addition, these drivers will bring requirements for decreasing the consumption of energy and water.

2. Strategic Research Agenda

Future agriculture production needs to be globally increased, with higher quality and using less land and fewer inputs at the same time. Earth observation can give us relevant information to help solve these problems on local, national and global levels. Satellite data are an important source of information for future agriculture. There is a clear need for new data, better spatial resolution, new bands and more dense data. However, the willingness and possibilities of farmers to pay for this are limited. The need for in situ data is another important issue, helping users to use remote sensing data optimally. The process of deriving useful information from satellite data that can help farmers to make precise decisions must be supported. Integration with aerial data and in-situ data is necessary. There is a need to increase spatial resolution (e.g., for the provision of soil water data) and temporal resolution (e.g., for the timely detection of crop disease and (near-)real-time monitoring). We need incorporation of more bands (e.g., thermal sensors to derive information about evapotranspiration or potentially improve often criticized Sentinel-2 cloud masks or L-Band and X-Band data for complementing information from the Sentinel-1 C-band constellation).

Satellite data, such as Copernicus and Landsat data, are available for free via many delivery platforms. The availability of other than satellite data is rather limited. A lot of data is delivered on a commercial basis. The idea is that European Data and Information Access Services (DIAS) will be self-financed, which could lead to the fact that some of them will not be operational after the end of their contracts. On the one hand, there are large investments from the public to private, to build new solutions and delivery platforms. On the other hand, agriculture is highly fragmented with enormous amounts of players in different sectors (e.g., machinery, insurance, fertiliser producers). Access to knowledge is limited and the current investments are not efficiently utilised. There is an urgent need to verify the investments for all public and private partners and get a deep understanding of the return of investment for all participants, as well as verification of climate change and/or environmental positive or negative effects.

A very innovative method that was proposed is to make use of social media and web data sources in future. As an example, in 2016, farmers tweeted about their low wheat yields; however, this situation was not picked up by early warning systems. Social media data therefore represent an interesting source of ground-based information that can inform early warning systems. The use of refined satellites with higher resolution and lower data latency will overcome the challenge and limitations of low spatial and temporal properties of current satellites. Remotely sensed data can be coupled with crop growth models and input data like climate information, soil type, plant varieties and management practices, not only to enable precise diagnosis of crop production, but also to foster crop forecasting such as crop performance and yield. These forecasts support policy makers and insurers with information about food security, trade, market access and avoidable crop damages due to weather extremes.

For the future perspective, a user-friendly dataset should be achieved that addresses the customer needs and their concrete requirements. Therefore, these data have to be

characterized by long-term support through workshops, constant exchange and updates. Because satellite remote sensing data can foster decision-making activities, it is essential to use this kind of data in areas where a lack of in situ observation occurs, such as countries with ongoing conflicts and political insecurities. Eventually, it is important to share and collect land surface information in order to develop robust policies and strategies for food management to build up a dense network to assess food security worldwide.

The availability of ancillary information/data (LPIS availability, weather data) is important for the development of any agricultural service. While the weather and meteorological data are commonly available through various services, LPIS data in the EU are fragmented and not available in every part of the EU as open data. In this sense, there is sometimes a privacy problem that can be solved by the use of modern Differential Privacy and Privacy Preserving Machine Learning (e.g., Federated Learning or anonymization). As an example, even without the full information from LPIS (e.g., polygons with real coordinates), it is possible to generate valuable training data made of pixels associated with crops and a generic set of features (e.g., lat/lon intervals, slope, height, climate area) to stimulate the development of new machine learning techniques. In this sense, the release of open datasets from EU institutions can be an important step to increase the quality of the agricultural EO services. The availability of models to downscale information for small parcels is also an important aspect as models are not harmonized and this should be a direction for the new research agenda.

Adoption of the European Green Deal will require changes to the Common Agriculture Policy and this will require the cooperation of all stakeholders' groups. There are two important aspects for this to find common trust for data sharing and implementation of the FAIR Data Principles (findable, accessible, interoperable, reusable). This could be supported by a new European strategy for data, but also by international initiatives like GEO/GEOSS. There is a need for discussion between the private and public sectors about the effective sharing of data and expenses. Since some services will be in the public interest, it seems natural that the public sector will cover part of the expenses.

How to build a solution, which will connect public and private interest and which will offer possibilities for sharing data and knowledge about different stakeholders' groups? In addition, how can we do it without destroying the market? On the one side, it is a question of an agreement with data producers or service providers and the public sector. This agreement can be complicated. On the other hand, such agreements can close markets for other players and can lead to monopolies and can exclude new investments and also the entrance of new players to the market [6].

3. Conclusions

Based on the previous analysis, a set of recommendations is proposed to:

1. Organise regular workshops and conferences of all interested stakeholders. These workshops and conferences have to lead to the exchange of information, but they also need to educate all stakeholders about new methods. 2. Support cooperation of all players from the public and private sectors to fulfil the European Green Deal, Destination Earths and SD goals. It will also invite the food industry, machinery, chemical industry, IT industry and financing organizations to build a common environment. 3. Support new common multi-actor research involving both EO and agriculture/agronomy experts to develop new methods that guarantee food security and agriculture sustainability. 4. Support the farming sector with open data, including Copernicus and other EO data. This will require additional investments. Put into the practice FAIR principles. 5. Develop new metadata models and strategy for sharing all data across agriculture. 6. Reuse previous solutions. On the one side, continue with the development of new technologies and EO methods to build future Digital Twins. On the other side, there exists a large potential of existing technologies recently developed, that their potential is not fully exploited. It is necessary to prepare an overview of existing technologies and discussion among the teams on how to make solutions interoperable and how to reuse existing solutions. 7. Finance a

large number of smaller independent projects for technical development. This can bring new ideas in the short term. SmartAgriHubs can be used as an example. 8. Support standardization efforts and use of existing standards. This needs to be done in cooperation with existing standardization bodies including OGC, ISO and W3C. 9. Support large scale coordination actions, which will improve cooperation among different projects, initiatives and standardisation organizations. This needs to support both standardisation and FAIR principles. 10. There exist several technical problems, but the biggest problem will be at the level of legislation and financing. It will require a reform of the Common Agriculture Policy and also build effective strategies. This cannot be done only on a political level, but it will require communication of politicians with technical experts and researchers to define a successful strategy. For this purpose, it is necessary to establish a forum, where all these players will meet. A new strategy has to be prepared based on expert opinions and scientific results.

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